to perform fusion of ultrasound and volumetric cardiac images (e.g., MR or CT) for joint function, flow, anatomy, and coronary assessment. Previous registrations techniques require explicitly defining a segmentation of a coronary structure (e.g., full heart, chamber(s), valve) or anatomical landmarks. The above described methods enable the fusion of ultrasound and volumetric cardiac image (e.g., MR or CT) without the need to explicitly define a segmentation or landmarks.

[0147] In another embodiment, the above described methods of intelligent agent based image registration may be applied to register CT or MR images to ConeBeam CT images. Interventional ConeBeam CT is often used to guide surgeries or interventions (e.g., cardiac interventions, spine surgery, etc.). Interventional ConeBeam CT often suffers from image artifacts dues to device, which makes robust image registration difficult using previous registration techniques. The above described methods provides robust registration of CT or MR images to Conebeam CT images even in images with noise or image artifacts, which allows to image data from the pre-operative CT or MR images to be fused with the interventional ConeBeam CT images used for guiding an intervention or surgical procedure.

[0148] In another embodiment, the above described methods of intelligent agent based image registration may be applied to perform automatic change detection through deformable registration. For example, a previously acquired medical image of a patient and a follow-up medical image of the same patient can be registered using the above described methods for intelligent agent based deformable image registration in order to determine a deformation field that shows changes to the anatomy of the patient over time. Such automatic change detection can be used in cancer screening to detect tumor growth or reduction over time, to track changes in stenoses, plaques, or other abnormalities in coronary arteries or other vessels, or to track changes in any other anatomical structure of patient due to disease or treatment.

[0149] In another embodiment, the above described methods for intelligent agent based image registration can be used to perform motion compensation. For example, when registering a pre-operative medical image (e.g., CT or MR) to intraoperative/interventional medical images acquired during a procedure, a trained intelligent artificial agent for image registration can be kept always running in a perpetual state as real-time interventional medical images are acquired and the images are always registered even when movement occurs in the real-time interventional images (e.g., due to patient movement, respiratory motion, or cardiac motion). Using the above described methods, the intelligent artificial agent automatically re-registers the images as the interventional medical images are received in real-time, such that the registration immediately "catches up" to the movement in the real-time images, thus allowing for real-time perpetual compensation of respiratory motion.

[0150] The above-described methods for intelligent agent based image registration can be implemented on one or more computers using well-known computer processors, memory units, storage devices, computer software, and other components. A high-level block diagram of such a computer is illustrated in FIG. **23**. Computer **2302** contains a processor **2304**, which controls the overall operation of the computer **2302** by executing computer program instructions which define such operation. The computer program instructions may be stored in a storage device **2312** (e.g., magnetic disk) and loaded into memory **2310** when execution of the computer program instructions is desired. Thus, the method steps illustrated in FIGS. **2**, **3**, **4**, **5**, **6**, **7**, **10**, **12**, **14**, **17**, **18**, **19**, and **22** may be defined by the computer program instructions stored in the memory **2310** and/or storage **2312** and controlled by the processor **2304** executing the computer program instructions. One or more image acquisition devices **2320**, such as a CT scanning device, C-arm image acquisition device, MR scanning device, Ultrasound device, etc., can be connected to the computer **2302** to input image data to the computer **2302**. It is possible that the computer and one or more of the image acquisition devices **2320** may be implemented as one device. It is also possible that the image acquisition devices **2320** and the computer **2302** communicate wirelessly through a network or wireless communication protocol. In a possible embodiment, the computer **2302** may be located remotely with respect to the image acquisition devices **2320** and may perform some or all of the method steps of FIGS. **2**, **3**, **4**, **5**, **6**, **7**, **10**, **12**, **14**, **17**, **18**, **19**, and **22** as part of a server or cloud based service. The computer **2302** also includes one or more network interfaces **2306** for communicating with other devices via a network. The computer **2302** also includes other input/output devices **908** that enable user interaction with the computer **2302** (e.g., display, keyboard, mouse, speakers, buttons, etc.). One skilled in the art will recognize that an implementation of an actual computer could contain other components as well, and that FIG. **9** is a high level representation of some of the components of such a computer for illustrative purposes.

[0151] The above described methods for intelligent artificial agent based image registration and/or training deep neural networks may be implemented in network-based cloud computing system. In such a network-based cloud computing system, a server communicates with one or more client computers via a network. A client computer may communicate with the server via a network browser application residing and operating on the client computer, for example. A client computer may store data on the server and access the data via the network. A client computer may transmit requests for data, or requests for online services, to the server via the network. The server may perform requested services and provide data to the client computer (s). The server may also transmit data adapted to cause a client computer to perform a specified function, e.g., to perform a calculation, to display specified data on a screen, etc. Certain steps of the above described methods may be performed by a server or by other computers/processors in the network-based cloud-computing system. Certain steps of the above described methods may be performed locally by a client computer in a network-based cloud computing system. The steps of the above described methods for intelligent artificial agent based image registration and/or training deep neural networks may be implemented in network-based cloud computing system may be performed by the network-based cloud-computing system or by a local client computer in any combination. In one embodiment, one or more trained artificial intelligent agents are stored on a server or other remote computer device in the network-based cloud-computing system, and a client computer electronically transmits two or more medical images to be registered to the server of the network-based cloud-computing system. The server and/or other computers/processors in the network-based cloud-computing system performs the